

Oxygen Insensitive Anodes: Towards a Printable Lithium-Ion Battery

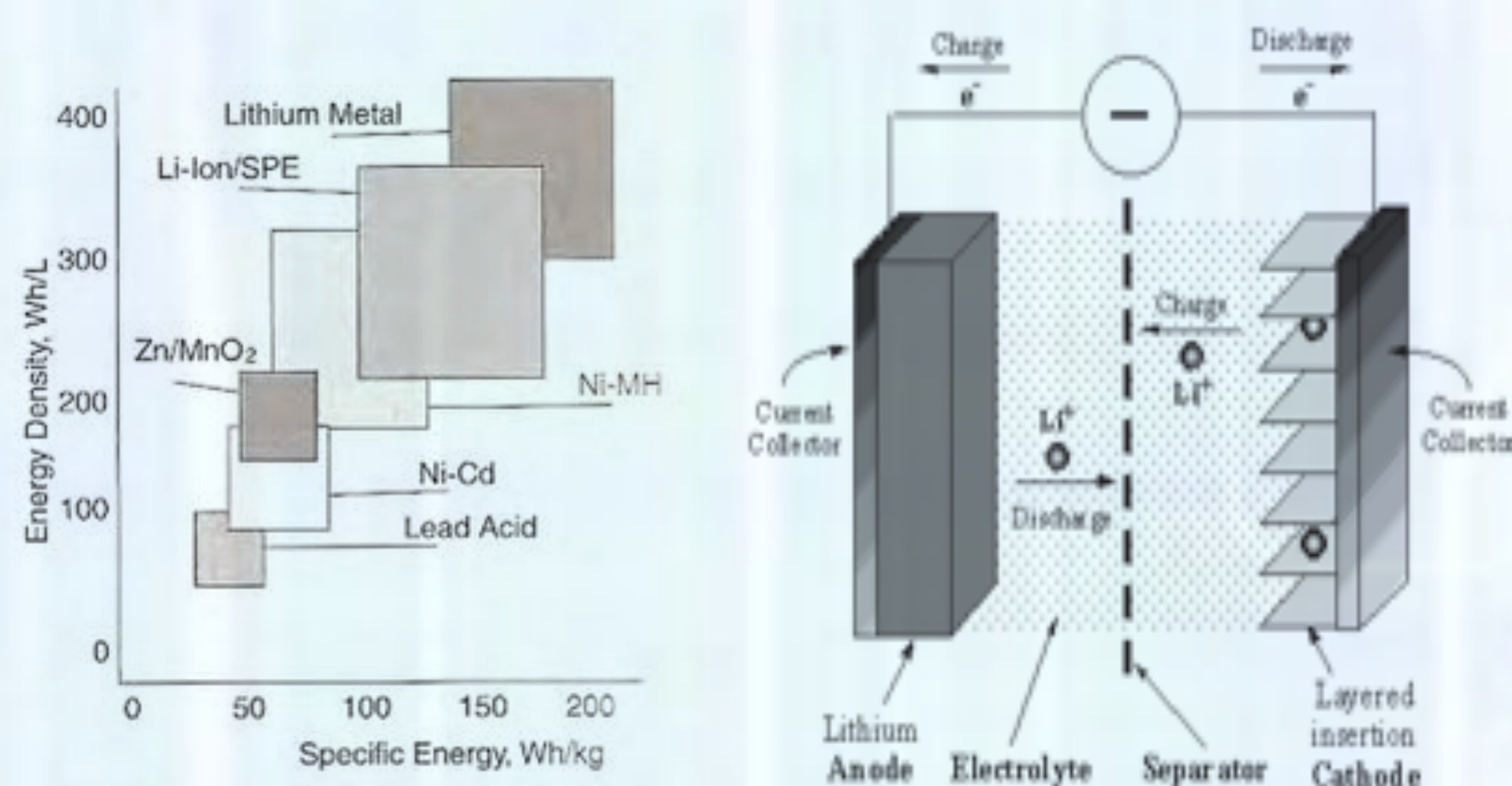


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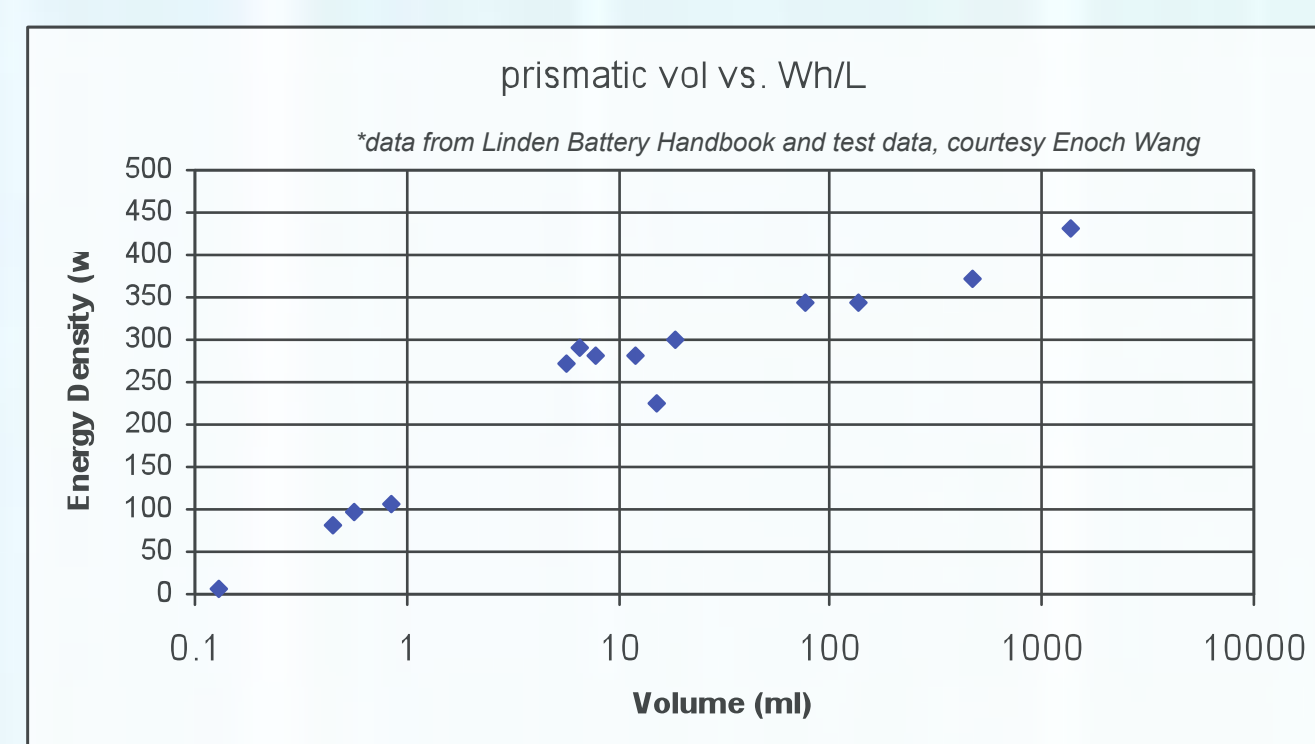
Problem

Battery Basics: Energy Storage for Batteries is limited by chemistry and architecture



Chemistry sets the potential of the battery, and can decide both the energy density and the specific energy of the battery

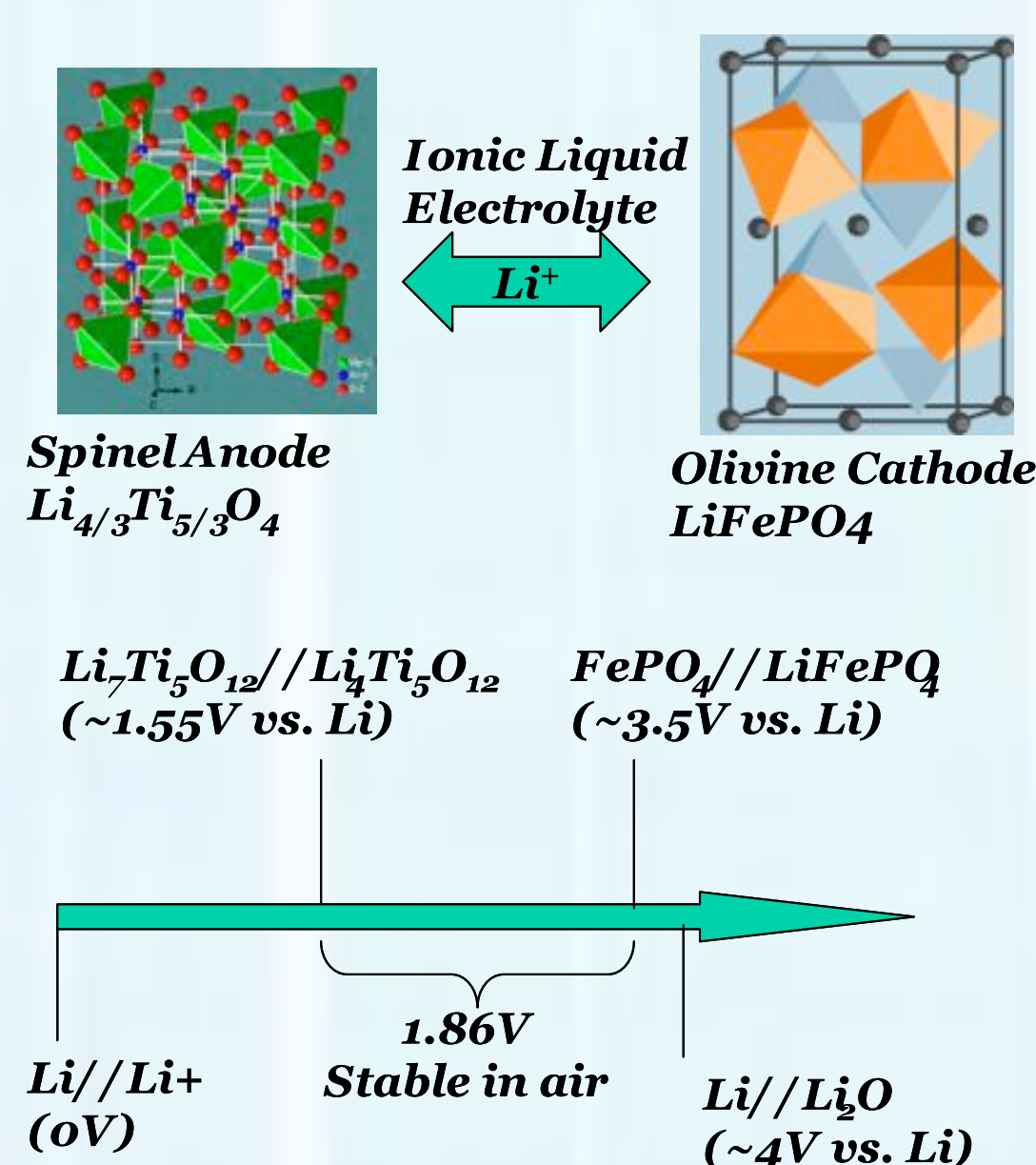
Architecture sets the conditions for how fast the battery can charge and discharge, and also what energy density is realized in the battery; materials choices can also limit cycle life



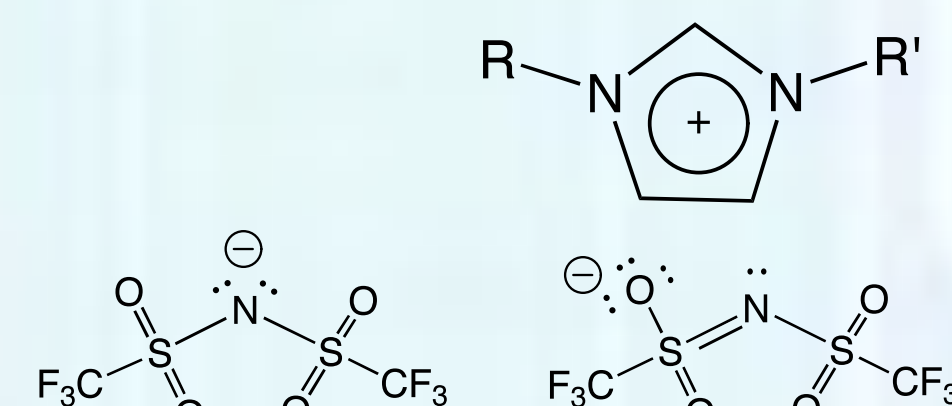
Making Batteries smaller involves challenges in both picking a compatible battery chemistry, and working to reduce the volume of inert material in the architecture

Approach

If you pick the right chemistry, then you don't need a package

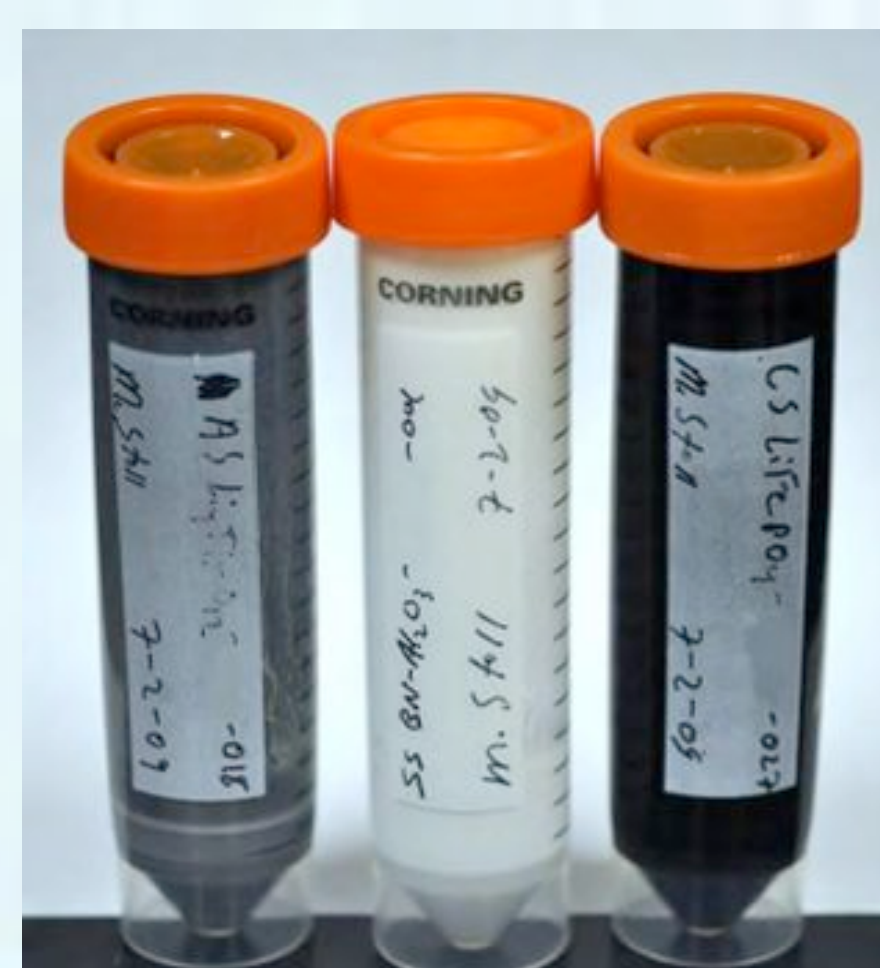


Intercalation Electrodes are chosen for lithium electrochemical stability in the open air; if an anode is chosen that is too low in potential, the lithium will oxidize, if the cathode is chosen too high, oxygen will be reduced, instead of running the battery electrochemistry

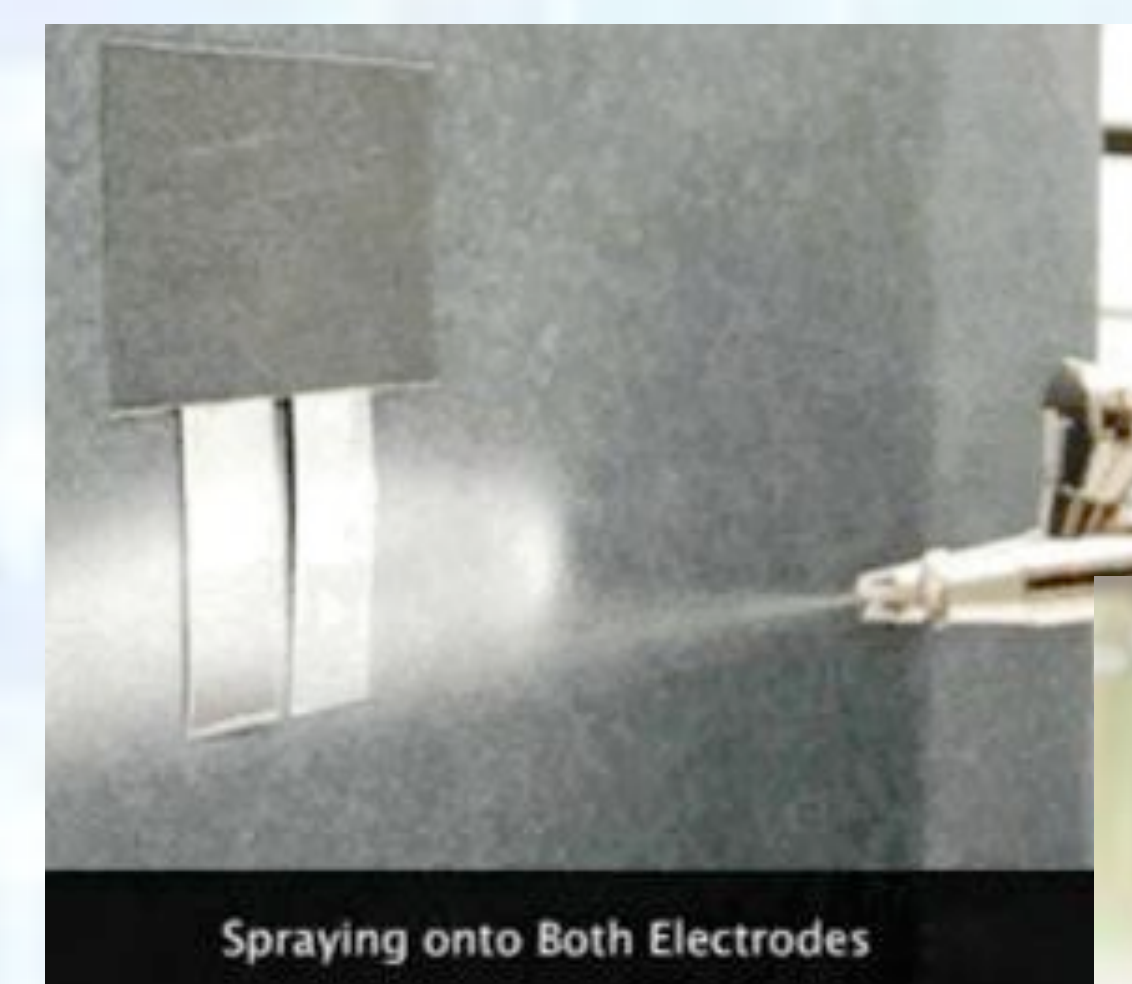


Ionic liquids are used as electrolyte solvents because they have very low vapor pressures and low oxygen solubilities. These give protection to the lithium ion while it's solvated in the electrolyte

Rheology of each material (current collector, cathode, separator, and anode) are adjusted to make an ink that dries to the correct microstructure and morphology to produce a good battery after spray painting.



Results

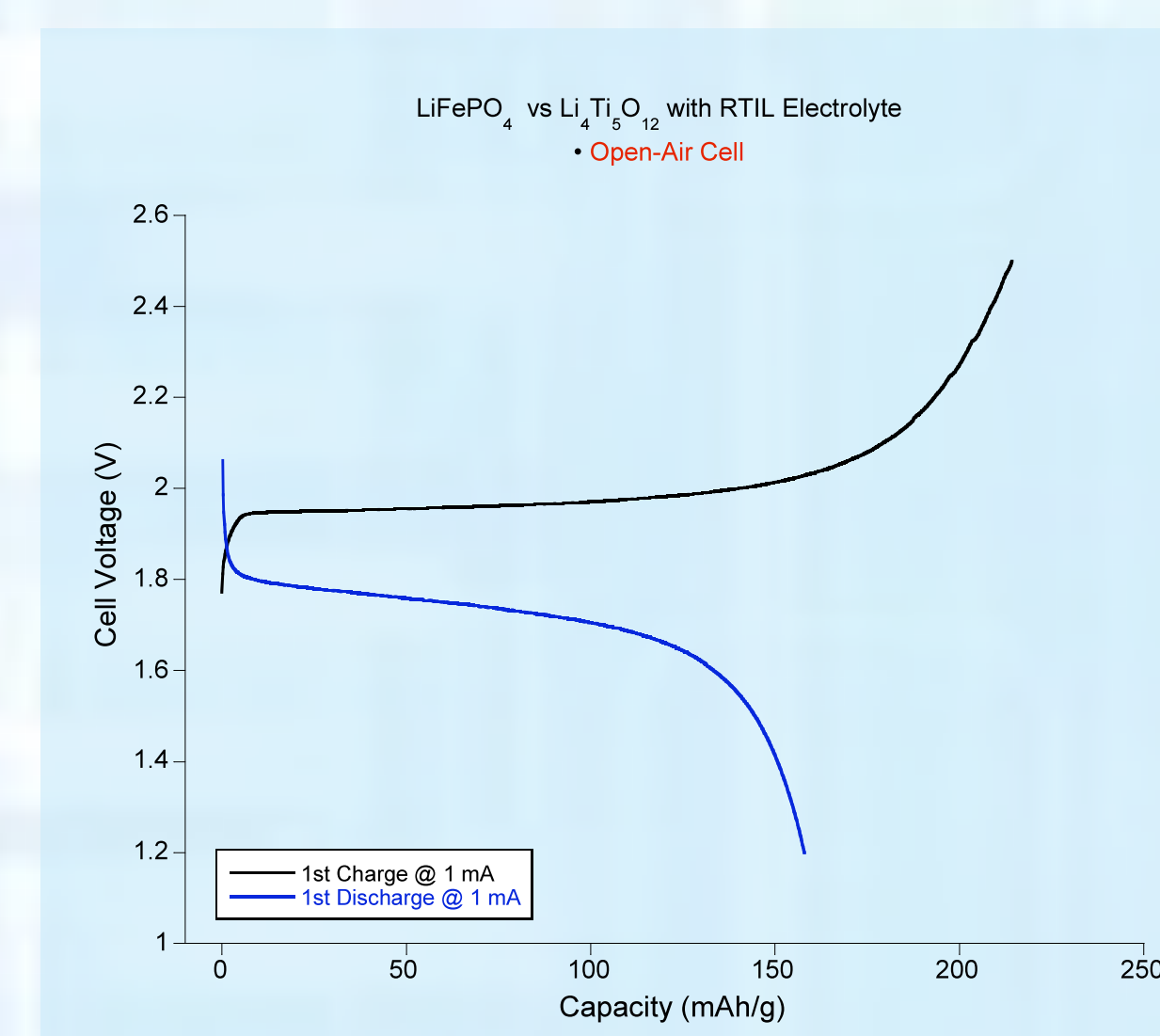
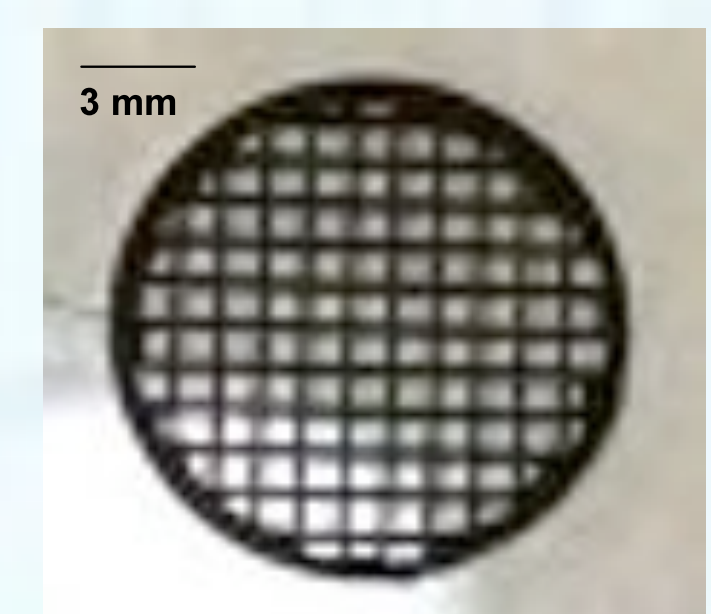


Spray Coating a battery separator onto previously coated anode and cathodes (coated onto aluminum current collectors)

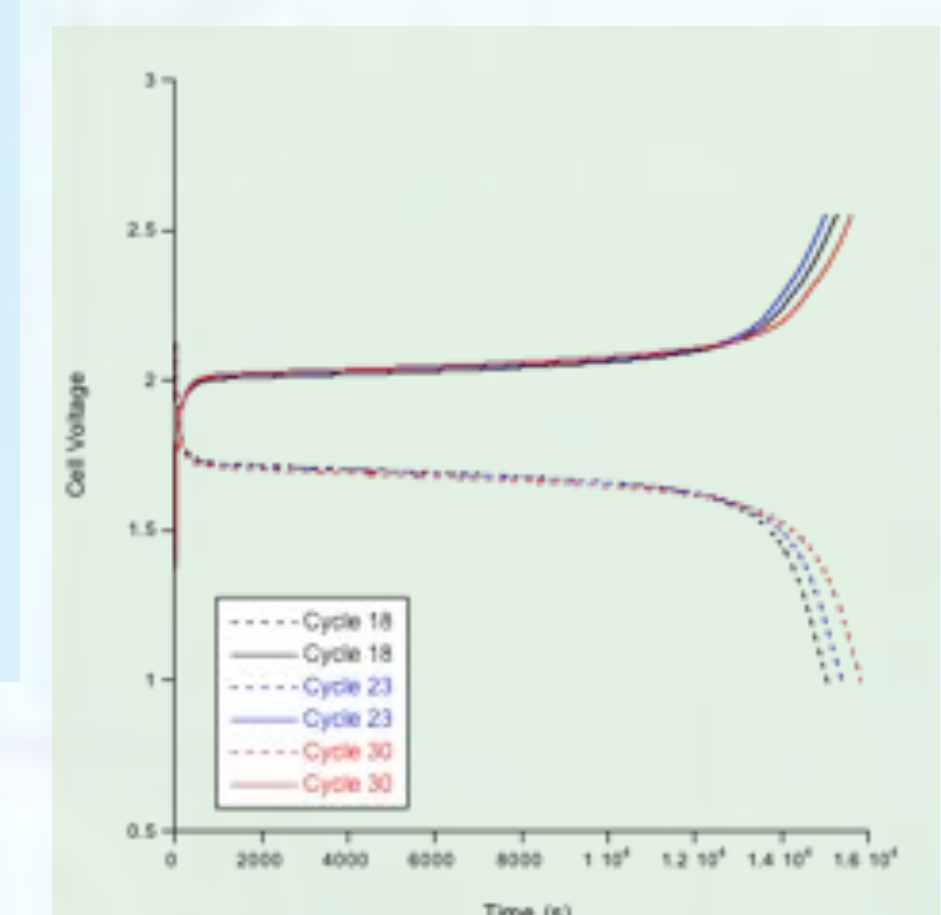


35:1 Aspect Ratio!

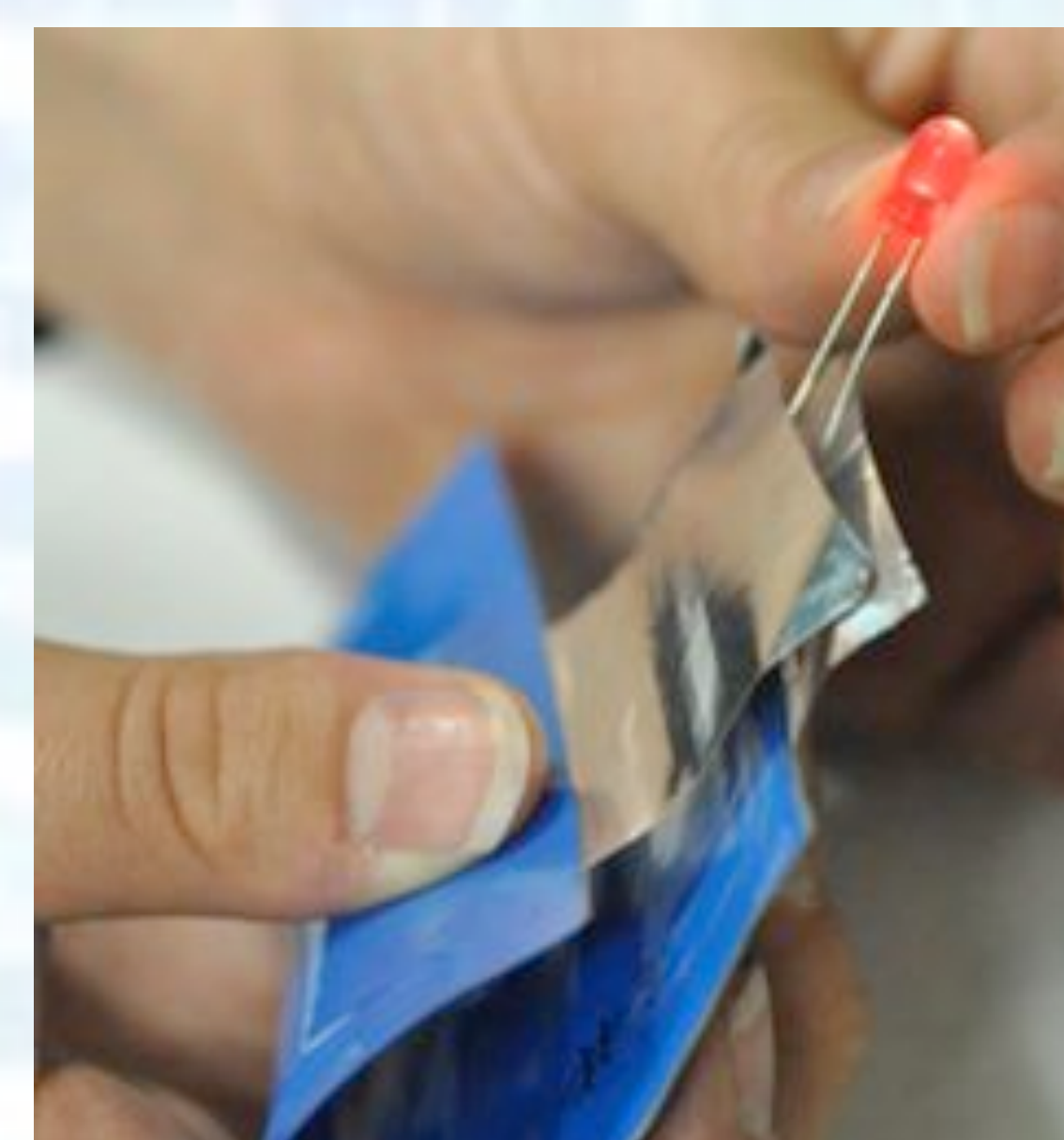
Direct Printing of anode and cathode material using spinneret techniques allows for structuring of the battery for unique needs



Charge/Discharge characteristics of a printed battery show good voltage performance out to a large percentage of the theoretical capacity (168mA-hr/g)



Cycle Life needs more testing, but initial tests are encouraging



Flexible, foldable architecture

Significance

New batteries, new applications

Oxygen tolerant lithium-ion based battery chemistry has been demonstrated that can produce a battery that does not need a package to operate. This change in chemistry allows for a significant gain in energy density by removing the majority of the inert components of the battery (package, thick separator). Instead, a spray coating compatible separator has been demonstrated that allows for the battery to be printed in open air, and then charged and operated as a normal battery.